**Russell:** Thanks for downloading Inside Octopus. My name is Russell Goldsmith. For the first time on this series, instead of producing the show online, we've actually recorded it on location, as I visited Octopus Energy's brand new 10 million pound flagship training and R&D centre in Slough to get an exclusive pre-launch tour of the facilities and discuss why heat pumps are the future of heating.

Following all the COVID guidelines to be there, I was joined by four members of the octopus team. Clem Cowton, Director of External Affairs, John Szimik, CEO of Octopus Energy Services, and then newer recruits Aimee Clark, Head of Commercial and an expert in bringing new, smart tech to the mass market, and finally Peter Konowalczyk, a leading physicist and pioneer in the heat pump space.

I started the discussion by asking John to explain where we were actually recording the show.

**John:** So we're in our new state of the art facility, just outside of London. It's a training and R&D facility. We'll try and train upwards of a thousand engineers a year to install renewable heating systems, from the end of this year onwards. It's huge. It's big enough to build about 20 homes in here. We've currently got two full size houses that we'll be training on, and I think we're going to do a walk around later, so we'll talk a bit more about the detail then.
 **Russell:** Yeah, very much looking forward to our tour later, John, but let's kick off this episode. We're here to talk about heat pumps and why you guys believe they are the future of heating. So Clem, maybe you can start by just explaining the reasons why we need to decarbonize heating.

**Clem:** Well from a very high level manmade climate change is killing the planet and we're running out of time to stop it. So our government and many governments around the world are trying to put in place policies that will enable us to stop burning the gasses that cause

that climate change and those extreme weather events. One of the biggest culprits, particularly in the UK, is the gas that we burn in our homes to keep us warm and to cook our food and that heating in the UK accounts for about 14% of our emissions. So it’s a huge, huge check that's just not really been addressed yet.

One of the best ways to do that. Not just in heating, but just generally, is to electrify because we're able to make electricity cleanly from natural resources, like the wind and the Sun, and those resources are abundant and free, so if we can harness them, we can make very cheap electricity, and in turn, we can use that to turn into clean heating.

So by doing so will not only help to address the UK contributions to man made climate change, but we'll also be able to stop burning gas inside our homes and hopefully make our homes more modern, safer, cleaner, and have a more enjoyable heating experience.

**Russell:** So do we know how many homes in the UK have gas boilers?

**Clem:** It’s about 18 million homes so it's a massive, massive number, and actually we're installing 1.7 million gas boilers every year. So we're actually increasing that problem. That's good news though because it also means that if we, if we moved to it, electric sorts of heating, instead we can overcome it within sort of 10 short years, if we can carry on at the pace that we're going at the moment.

**Russell:** Peter, why do you believe heat pumps are the answer then? Because I've seen a lot of media coverage about them recently, and often the same challenges are highlighted, in that they cost £10,000 versus £2,500 for a gas boiler, you've got to re-pipe the whole house, you may need new radiators, the hot water doesn't become hot. Are they realistic?

**Peter:** It's very frustrating to answer questions like that because actually it is absolutely possible to heat up houses by using heat pumps rather than gas boilers. Look, heat pumps are really old technology. People don't know that actually heat pump is more than 100 years old as a technology. In 1748 the first artificial refrigeration was established or designed by a Scottish engineer. And at that time, of course, we didn't have enough technology to develop it and build it, but right now, heat pumps are really established. If you look at that, we are all familiar with air conditioners. We all have fridges and freezers in our homes. We have cars with air conditioning. This is a normal and natural part of our life. So it is sad that I have to quite often explain to people that heat pump are actually what they already use.

Gas boiler, the unit, which does internal combustion. So you burn in gas inside the house and by burning gas, you produce hot water and heating. However, when you look at heat pumps actually, as a technology, it's very simple. Heat pumps actually harvest energy from outdoors, for example - air source heat pumps - and add a little bit of electricity and actually produce heating on the other end. There's no burning. Nothing. It's just a very, very simple device. If you look at a standard heat pump, efficiency is around three to four COP (Coefficient of performance), so this is when you have one kilowatt of input of electricity, you have three kilowatts harvested from outdoors, so you produce four kilowatts of output. So this will give you COP 4 but when you compare with COP numbers, the gas boiler, rather than having 4, has got 0.9. So this takes so much to achieve what a heat pump can just easily achieve.

I cannot believe that people really ask how heat pumps can heat up our houses. If we size heat pumps correctly, to house heat loads, if we size correctly - the hot water cylinders - we never run out of hot water. We will never feel cold. It will always work with us. And as long as heat pumps can provide enough energy to compensate heat losses, we'll be fine. And actually sizing radiators - yes - sometimes houses have very small radiators and they need to be replaced. Sometimes we have to think about slightly bigger pipes. We try to avoid that, obviously, because this will require bigger work, but 90% of houses do not need to be very deeply updated. They can easily be compatible with existing heat pumps, especially new heat pumps when they can work with much higher temperatures.

**Russell:** So Peter, let me just understand this, right? You take one unit of energy and then you turn that into an additional three. How does that work exactly?

**Peter:** Okay, so let me explain it. You take one unit of electricity, and this electricity will actually be used to harvest energy from outside. So you take one unit of electricity. You harvest three units of heat from outside. And in total you have four units of heat, which you can utilize to heat up your house or hot water. Is actually quite a simple process. Fluid inside the heat pump does the main work and actually the heat pump is like a fridge. You have a cold side and you have a hot side. As with a fridge, we use the cold side as a place where we store food. Actually, heat pump works in reverse. So we use the hot part of the fridge to heat up our house and the cold side sits outside.

When you have a correctly sized heat pump, when compared to, for example, a boiler, where you'll have to use a strong boiler to heat up a house (when you work in reactive mode) - so when you heat up water, you have to do it very quickly - heat pumps can work very slowly and gently. And in this case you can use much smaller units than boilers. Boilers are typically 30 kilowatts. Heat pumps - to heat up a house - will be like 10 kilowatts maximum - 6 quite often. So actually the size of the heat pump doesn't have to be that big. and still, based on a good controller, good understanding of human behaviour and a good understanding of weather conditions is very important, a heat pump can prepare your house for you. So before you arrive, a heat pump can start heating this up, and a heat pump can produce hot water as well. On good time when actually it's cheaper energy and heat pump can work for you, with you, rather than like a boiler where you have very quick reaction, which actually is unnecessarily.

**Russell:** So this makes it a much more efficient system?

**Peter:** Absolutely. Yes. Again, as I said, one kilowatts of electricity can give us four kilowatts of heat in total. This is fantastic compared to a boiler, which is efficiency 0.9, heat pump has got efficiency 4 - that's a very big difference between both.

**Aimee:** And just to add on that, the efficiency means in terms of carbon impact is if you've got, you know, a quarter less energy, it's roughly a quarter less carbon as well. So in terms of our kind of overall objective in terms of moving to Net Zero, if everyone got a heat pump installed in their home, that would wipe out three quarters of their (heating) carbon footprint. And as we invest more in renewables and the grid becomes more green, that will eventually go to a hundred percent and there'll be completely net zero.

**Peter:** There's one more thing which I want to add. A heat pump doesn’t burn any gas. That’s very important. A Heat pump doesn't emit any NOS or any CO2. A heat pump is very, very green.

**Clem:** It's important to clarify that NOS is a gas a bit like carbon dioxide that also contributes to climate change, but more so than that, it's toxic inside the home. It actually contributes to asthma, particularly childhood asthma, poor air quality in the UK kills around 30,000 people every year. So this is a very serious problem that we need to address. And part of that problem is inside our homes with the poisonous gases that we’re burning there.

**Peter:** But this is one of the answers. This is like a technology answer. Yes. I believe - actually John can answer as well - from an installation perspective, as a large part of a heat pump is actually installation costs. This is the part where proper savings can appear.

**Russell:** Well, John, do you want, do you want to pick that up then? I mean, why aren't there more heat pumps in UK homes right now?

**John:** Well, I think there's a number of reasons and challenges, but these are things that Octopus are looking to overcome. Cost is currently an issue. A heat pump installation is around 10,000 pounds for an average sized property versus 2,000 or 3,000 pounds for a gas boiler. It’s technology that people aren't hugely familiar with either.

I think to understand why it costs so much, you kind of really need to know how the industry works at the moment and it’s effectively an industry that’s stitched together with small installers that, you know, don't necessarily have to have the buying power or the resources available to really drive down the cost and the unoptimized installation processes in order to bring these costs down. That's something we can do because we can do this at scale. So we will optimize installation processes as Peter points out. We'll make sure that we've got the right people, the right skills, the right parts for the job, so that we can reduce the install time, and that will directly bring down the cost of these units.

It's not something we'll do on our own. We want to continue working with third-party installers across the country. We do that now with other technologies and that will always be the case, but we also want to work with manufacturers and the partners that share the vision to decarbonize heating with us to ensure that we get the best possible price for the hardware, so that when you combine the reduced installation cost and reduced hardware cost, you significantly drive that price down.

And for us, that's the key starting point. Bring the price down to a point where it's parable with a gas boiler exchange, and then all the other benefits around heat pumps that we've talked about already, and we'll continue to talk about in this podcast, will be accessible for the mass market.
 **Clem:** And just listening to what both Peter and John were saying, you see massive parallels with electric vehicles. I mean, my Nana drove an electric van during the second world war, and yet it was only when Tesla came into the market and really created a kind of mass consumer product that those costs started to come down. And we're now seeing a revolution in how we drive around our roads, the same will be true of heat pumps. It's not a new technology. So there's a kind of reassurance that we know how it works and we've got it down. It's not rocket science in terms of how we create the actual technology, but the smart bit is creating a mass market where people really want it. It's easy. It's tangible.

People can just see immediately that it works better than what they've got already. And by driving that scale, we're able to then - through the combined innovation of John and Peter and their teams - we were able to create this product that the majority of people in the UK will have in their homes within the next 10 to 15 years.

**Aimee:** Absolutely. I mean, 40% of people say their next car choice will be an EV, and you can see heat pumps being there in a few years time.

**Peter:** And this is exactly why I wanted to join Octopus. I see Octopus like a Tesla of heat pumps. This is the company where rather than talk about electrification of heat, this company wants to do it. This is why I’m here.

**Russell:** Well, Aimee, what about the cost to run these? How does that compare?

**Aimee:** That's definitely another barrier we're looking to overcome. So despite the fact that heat pumps are so much more efficient, as Peter said, they're four times as efficient as your average gas boiler. Because of the way gas and electricity is priced, a lot of the taxes applied just on the elec and not on the gas. That means electricity is five times more expensive than gas. So when you net those two things off, it's still more expensive to run a heat pump than a gas boiler today, we're trying to tackle that. And so we've got some customers using our smart tariffs, like our Agile tariff, which varies based on how much green energy there is on the grid. And through using that and programming the heat pumps to run more in off peak times - so putting it on and say a couple of hours before the peak period in the evening, we've been able to reduce that gap almost to zero. So, it definitely can be done. But to really drive the savings for customers and reach the majority of homes in the UK that's where we need the policy changes, which I'm sure Clem will have a few things to say about.

**Clem:** Well, yeah, I was just thinking about the fact that - this quote may not actually be originally from him, but Sam Hall who's the director of the conservative environment network recently described it as being like putting the, the sugar tax on bottled water. You've got a fuel that is already 40% renewable and getting cleaner all the time, being taxed 10 times more than a fuel that is dirty and is causing not only safety issues in our homes, but also contributing to climate change. The way that you incentivize behaviour changes, that you make it cheap and easiest for people to move to the alternative technology, as you know, fuel duty on petrol has made filling up a tank of petrol much more expensive than just plugging it into your socket at home. And that's the kind of position we need to get to with heat pumps.

It's actually closer than we think. The government recognizes that this disparity exists and actually a state for energy mentioned in an interview in The Times at the beginning of July, the fact that the government was really concerned about the differential between the taxes paid on gas and on electricity. And that disparity, that that creates in terms of how we're asking people to change their behavior. So it's definitely on the government's radar.

I think there's been a little bit of a nervousness historically about the ability of companies in the market to really drive that consumer demand and make a product that people want. They're a little bit nervous that if they take the taxes off electricity and perhaps put a few more of them on gas, all that will happen is that you'll be left with the same problem and nobody will step into the market and find the products that people want. Actually, what we're saying is we're able to do. We've done it before with electric vehicles and with renewable energy. And now we're able to come into the market and make a product that people will really want, and that will accelerate our transition to a zero carbon economy.

**Russell:** Are Octopus Energy doing anything in particular in terms of working with government on these policies?

**Clem:** The way we tend to work with government is to open up, you know, to be transparent, to show what we're doing, show our workings. So yes, we've been working, you know, I don't want to say ‘closely’ with government because government makes their own policies, but we have given them the tools they need to understand the reality of the market we're working in.

Historically, governments tend to have been told by businesses who'd really liked lots of subsidies that the products that they're making a very expensive because they want the government to subsidize those products. Actually, we're coming into government with a very different message saying, we're going to make these products very cheap. Just take the brakes off and you know, we'll show you what we can do. And I think that reassurance means that governments, that you know, that this government is starting to think a lot more seriously about how we tackle this as a mass market proposition, rather than, than perhaps what was historically the case - which is that we would, try to find a few off gas grid homes with oil agars, and try to just do those few very difficult homes.

We're now starting to think bigger and much more ambitiously about how we can put heat pumps into the vast majority of homes in a way that is a much more enjoyable heating experience.

**Russell:** So once you've got a heat pump installed, how long is that going to last?

**Clem:** So typically they last over 20 years compared to about 10 to 15 years for about gas boiler. And that's because there's much fewer moving parts. It's a much lower temperature. So with a gas boiler, you have a combustion chamber and you're literally burning stuff. Pump, it doesn't tend to get above say 55 degrees. So that means it's much easier to maintain and also less likely to break down and last longer, it's a bit like having a fridge in your home. If you think about how many times that's broken down, it's probably much less than say a boiler. So that's another key benefit that heat pumps will biring.

**Russell:** So Amy, if these policy changes are implemented, You know, is everyone going to be getting a heat pump?

**Aimee:** Absolutely. So we've done some initial testing with our customers and, and the general public, and the response has been overwhelming. So we found when you position heat pumps in a simple way, we call them green boilers because that's what they are - the green alternative to heat your home. And at an affordable price - so with the prices we believe we can get to with all the work we're doing in the center - and you have a really simple customer journey, there's huge interest. So we put a page live on our website and within a few days we had over 2000 signups. The challenge is most people only replace the heating when the current boiler is about to break. So at that point, there's quite a distressed situation. You need something that's affordable within a few thousand pounds. You need it installed quickly and it needs to be really simple. So that's what we're looking to achieve through all of the optimization work we're doing here. We're not just looking at cost, we're looking at all of those things. So when they go to replace their boiler, heat pumps are a no brainer.

**Clem:** I think it's often worth thinking about what would we do if we were starting from scratch pre-industrial revolution, perhaps, before, you know, before we all had coal being lumped into our homes, would we have thought the best way in the future that will, that will heat our homes as well, pumps and explosive gas into a very noisy box on the wall and then burn it. Probably not? So now that we've got electricity - we've got these incredible technologies - it seems kind of almost insane not to use them. They're much safer. They're much cleaner and you get a better experience. We shouldn't sort of shackle ourselves to the solutions of the past, just because that's what we're used to.

**Russell:** Okay well, as I mentioned at the top of the show, we're having this conversation at your brand new training and R&D center. So John, should we head out for a tour so you can tell us a little bit more about what you have here and how that's going to help in getting heat pumps into more homes?

So John, we've started the tour, just explain where we are first of all then.

**John:** Yeah. So here we are inside the demonstration room. The point of this is to bring visitors to show them what the future technology inside a renewable home would look like. So, what we're looking at here is an example of how you could electrify your home. So you could run your car, charging, your heating, you’d have battery storage. All running from green, renewable electricity that we've generated and supplied to you.

**Russell:** So, yeah, I was just going to say for the sake of those listening, because obviously, I mean, we'll have some supporting images for social media, but can you just explain what we can see on the wall?

**John:** Yeah. So what we're looking at is a smart meter, which is a vital enabler to be able to run all the other renewable technologies, and the smart meter rollout program is in full swing now. So we've got a smart meter through to some batteries. So these are ‘give energy’ battery units, which actually store excess power. So if you've got solar panels, for example, and you can store the power that you're not using and use that later on. We've got a vehicle-to-grid charger here. So these are incredible pieces of kit. What this does is it allows you to charge a bit. But it can also take power from your vehicle and put that back onto the grid or into your battery. So at times when energy is being generated from non-renewable sources, for example, and when it's particularly expensive, you can actually extract the surplus power from your car. At times when the energy grid is very green and the prices therefore typically are lower as well, you can take power and put it into your car. So it just allows you to almost run a mini energy centre at home, which is really exciting technology. We actually have got a vehicle inside here to show people you know, how that would connect to the charger and how that works. So we've driven that in very, very carefully. And then just on the other side here, we've got an example of a wind turbine. Octopus invest in renewable generation so we do actually have wind turbines in the UK and there's a solar panel on the wall there as well. Again, we generate a lot of renewable energy from solar in the UK.

**Russell:** So this is already looking good, but I know the real big stuff is behind this wall here.

**John:** Yeah, so we've got a switch glass wall here that's frosted, so when our visitors are ready, we can flip the switch and then they'll be able to see what's on the other side of there. And if we walk around here. What you'll see Russ is we've got two full sized houses.

**Russell:** Wow, I mean for those - I'm trying to describe - obviously you're here every day, but this we’re kind of stood in what looks like a huge aircraft hangar, basically. I mean, this is massive.

**John:** It really is a massive space. You could probably drive an aircraft into it. No problem at all. We had an HTV in here actually the other day unloading, and it was just kind of tucked over in the corner of the building over there, but you're right. You kind of, you take the scale for granted a little bit when you're here every day. It's just in the corner of this building are two full-size, you know, three bedroom houses. What these are are two typical construction types that we'll come across. So these are effectively live training rigs for engineers.

So the first one we're looking at here, which is a nice white rendered house is a sort of 2000 era. This is a timber frame property, and this is typically how they would have been built. And this is built exactly as it would have been with the right sort of heating types, the right plumbing systems, right electrical systems. So that allows our engineers to practice on a more modern home. And what they'll be doing here is taking out a gas combi boiler, for example, and they'll be putting in an air source heat pump and vehicle charging and other technology, maybe battery storage, like we looked at just there.

And next to that, we've got a 1970s brick built house. So again, this is built exactly how homes would have been built in the era. We had to find some very experienced builders that could remember exactly how all these houses were stitched together. Again, slightly different construction type, cavity walls - I’d say brick built, all the heating system is run with copper pipes and electric meters tucked under the cupboard under the stairs, which is where you typically find them in those types of properties. So again, this is another example of a live house where engineers can train to take, you know, heating systems in and out and practice to fully optimize.
 **Russell:** And just remind us how many engineers are going to be trained a year here?

**John:** We'll be training about a thousand engineers a year here, and those will be our own directly employed engineers. And we'll also be working with the third parties that we support. We have a network of smaller organizations across the UK that we work very closely with and we’ll want to continue to do that.

**Russell:** And it's going to be every day?

**John:** Every day, day in, day out for business. As we drive customer demand, we’ll need to drive the number of qualified engineers that we have and you know, and that's what we'll start doing from later on this year.

**Russell:** Okay. So just to explain what - so we've moved past the houses now. I can see a whole load of pipe work. And boy, was that an original combi boiler? Is that right?

**John:** Yeah. I mean, I'm hoping that will ultimately become a museum piece. Right? Our objective here is to rip all of these out of properties in the UK and replace them with renewable heating, but there is a combi boiler system in a training rig here. So again, our engineers can practice how to decommission those systems - take that out of a property. And then you've got a series of training bays here with all different technologies in, so you take the old system out of one and in the training bay next to that, there'll be practicing and installing a heat pump system, for example, and the hot water tanks.

**Russell:** Just on the other side of this wall, then, this is where we've got the heat pumps. You've got a couple of different sizes here. Just explain the different kind of sizes - what are the differences?

**John:** So these heat pumps have different sizes for different property types, depending, you know on the size of your property you'll have a different heat demand and therefore you'll need a slightly different sized heat pump. So we've got everything from a typical heat pump that you would use here for a sort of two, three bedroom house to a slightly larger unit over there, which might be, you know, for a four or five bedroom property.

You know, we can tackle any property size with the different hardware. And we've got training rigs where engineers will be able to find and identify issues. Part of the ownership experience of a heat pump is that we will provide maintenance and servicing for those. They're much more reliable than a gas boiler as we talked about earlier, but on the rare occasion there might be a fault, to diagnose them - this is the sort of a training rig that you would use to practice that and try and identify those.

**Russell:** In here. It looks like we've got  something that's almost been dissected. We can see the inside and the all workings here. Just explain what we're looking at?

**John:** We've built this actually to show people what's inside that magic box that is a heat pump. So you've got this box of magic that sits on the outside of the house but really what's inside there is almost like a refrigeration unit that works in reverse as Peter described earlier.
So you've effectively got a fan, a heat exchanger, and a compressor. And what we can demonstrate here is drawing in cold air. And in this example, we're actually using the heat that we generate from that to warm up the water in the fish tank here just for demonstration purposes. But obviously in your house that would be warming up the water that's in your hot water tank for your showers and for your hot water out your taps and it would also be providing your hot water for your heating system for your radiators.

**Russell:** And it's not just the heat pumps that you're dealing with here, is it? Because we just walked past another area.

**John:** Yeah, absolutely. So we're installing about 10,000 smart meters a week at the moment. We have 500 engineers all across Great Britain installing those day in, day out. So what we've got here is training rigs for all different types of metering that engineers would come across. You can imagine that engineers come into homes and find all manner of ages and design and types of meters and existing positions. So this is to allow them to train on that.

We can also train them on electric vehicle charging point installations, battery storage installations, and as I said, gas and electricity meters there as well.

**Russell:** I need to ask this question because when we arrived here, we walked past the first part of this, as I said, which is like a huge aircraft hanger. And there's 10, very smartly branded up Octopus energy vans - just what's going on in this section here.

**John:** These are, these are actually the first half of our new order of fully electric van. So these are Peugeot electric vans. Our engineers will be driving these very very soon. As part of our drive for de-carbonization, we also have to think about the emissions of our fleet and we're electrifying our fleet, and these are the first examples of how we're doing that. So yeah, fully electric van - brand new - wrapped in the bright Octopus livery - you can’t miss these as they go down the street. And you'll spot the difference on these ones, because they've got a nice green glow in the dark electric cable running down the side so that people know the difference between these and the diesel version. So yeah, these are part of our new fleet and also what we've got here is a huge amount of space where we're going to have our R&D centre. So what we'll actually be doing here is testing the sorts of hardware that we were looking at earlier. So heat pump hardware, for example, and we'll be able to test that in weather chambers, where we can simulate weather conditions and weather patterns from any point in time. You know, all sorts of stress, testing, research and development, continuous innovation, which is going to be necessary as we kind of drive the rollout of heat pumps over the next few years.

**Russell:** John, thanks for that. It's just an incredible, incredible space and everything that you're doing in here. So I really appreciate the exclusive tour for Inside Octopus.

Well, that's actually it for this episode. So John, Aimee, Clem, and Peter, best of luck with all you're doing here. And thanks again for joining us on Inside Octopus. As always, if you've got any comments on anything we've discussed today, please do get in touch by the websites at octopus.energy or via the usual social channels. But for now from me, Russell Goldsmith, thanks for listening and goodbye.